

# ECOLOGICAL OBSERVATIONS ON THE VIRGINIA PITCH-NODULE MOTH, *PETROVA WENZELI* (KEARFOTT), INCLUDING A NOTE ON ITS NOMENCLATURE

(LEPIDOPTERA, OLETHREUTIDAE)

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## INTRODUCTION

The Virginia pitch-nodule moth, *Petrova wenzeli* (Kearfott), is a common insect which builds pitch nodules on twigs of Virginia pine, *Pinus virginiana* Miller. This nodule maker has been mentioned occasionally in taxonomic, faunistic, and economic literature, but ecological references to it are lacking.

The insect was studied in the field in Ohio during 1953 and in Maryland during 1955, and casual observations were made on it in Pennsylvania and Virginia. Study areas in Ohio were Waterloo and Hocking State Forests. In Maryland, 9 stations within a 20-mile radius of Washington, D. C., were used. All study and observation sites were naturally regenerated woodlands.

Determinations of *Petrova wenzeli* adults were made by the authors. Specimens reared during the study have been deposited in the U. S. National Museum, the collection of Cornell University, and the collections of A. E. Brower and C. P. Kimball. Eulophid and braconid parasites were determined respectively by B. D. Burks of the Insect Identification and Parasite Introduction Section, U. S. Department of Agriculture, and by C. F. W. Muesebeck of the U. S. National Museum. Pines were identified by the writers, with an occasional verification by E. L. Little, Jr., of the U. S. Forest Service Herbarium. Nomenclature of pines follows that of Rehder (1949).

## IDENTITY

Up to the present, another name—*Petrova virginiana* (Busck, 1914)—has usually been used for *P. wenzeli*. Kearfott (Smith, 1910) mentioned the species first, using the name *Rhyacionia wenzeli*, but Kearfott's statements were not regarded as having nomenclatural significance. Under present International Rules, however, they constitute an "indication" (see Mayr et al., 1953; Chap. 11) and the name *Petrova wenzeli* therefore has priority.

To delimit exactly *P. wenzeli*, a lectotype must be designated because Kearfott did not designate any one specimen as the type. So far as known, nine specimens in the American Museum of Natural History comprised the entire *P. wenzeli* syntype series. All nine specimens bear printed red "TYPE" labels. A male and a female, presumably intended by Kearfott as "co-types," also have handwritten type labels. The male, with label data as follows, is hereby designated lectotype of *P. wenzeli*: "Glo. Co. N. J. iss. v. 15, TYPE, Collection of W. D. Kearfott, *Rhyacionia wenzeli* Kearf. Type ♂." The remaining members of the syntype series ("lectoparatypes") are as follows, with each bearing the label "TYPE, Collection of W. D. Kearfott": "Glo. Co. N. J. iss. v. 15, *Rhyacionia wenzeli* Kearf. Type ♀"; ♂ "Glo. Co. N. J. iss. v. 18"; ♂ "Glo. Co. N. J. iss. v. 23"; ♂ "Red Bank, N. J. v. 16"; ♂ "Glo. Co. N. J. iss. v. 20, *Evetria virginiana* Busck AB 1917"; ♀ "Glo. Co. N. J. iss. v. 20"; "Glo. Co. N. J. iss. v. 24" (lacking

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abdomen); and "Glouc. Co. N. J. iss. v. 12" (lacking abdomen). The American Museum of Natural History has donated two of the lectoparatypes with abdomens to the U. S. National Museum.

Clearly, Kearfott rather than Smith was responsible for the *Petrova wenzeli* indication. On page 17 Smith (1910) says ". . . the list has been written by me with such help as is specifically acknowledged, except that the microlepidoptera are almost entirely the work of Mr. W. D. Kearfott." Also, the abbreviations "Kearf." and "Kf." appear in the indication.

The type of *Petrova virginiana* and the newly designated one of *P. wenzeli* are undoubtedly conspecific. Grounds for conserving the better known name (*P. virginiana*) are weak: so far as known, the organism has been mentioned in a total of nine published articles—averaging only two mentions a decade—with the name *P. virginiana* appearing in eight, and the name *P. wenzeli* in three. It seems highly unlikely that a change could cause enough confusion to warrant overriding the rule of priority. The present synonymy is as follows:

*Petrova wenzeli* (Kearfott)

*Rhyacionia wenzeli* Kearfott in Smith, 1910: 538 (type: Gloucester Co., New Jersey; Amer. Mus. Nat. Hist.).  
—Heinrich, 1923: 23 (unintentional.) —Forbes, 1923: 439 (unintentional).

*Evetria virginiana* Busck, 1914: 145 (type: Falls Church, Virginia; U. S. Nat. Mus.).

*Petrova virginiana*, Heinrich, 1923: 23. —McDunnough, 1939: no. 6755.

*Rhyacionia virginiana*, Forbes, 1923: 439.

#### LIFE HISTORY

*Petrova wenzeli* individuals normally require two years to complete their life cycle. Eggs are laid in the spring. They hatch in early summer. Young larvae construct resinous nodules (fig. 2) on current shoots; in these nodules they feed and overwinter. The following spring, the larvae migrate from the first-year nodules and construct new nodules (fig. 3) on older twigs, usually at crotches. The larvae pass their second winter in these nodules. They pupate early the next spring, and a month or more later the adults emerge and begin laying eggs.

*Egg stage.*—The writers never found eggs in the wild, and the moths never laid fertile eggs in captivity. Moths in glass containers laid infertile eggs which were flat and oval. The dimensions of 6 eggs averaged 0.78 by 0.94 mm. Microscopic examination showed reticulations in their chorionic membranes. The least time between field observations of first adult emergence and first activity of newborn larvae was 11 weeks. The incubation period is estimated to be seven or eight weeks.

*Larval stage.*—The earliest dates that larval work of a new generation was found were July 31, 1953, in Ohio and July 17, 1955, in Maryland. In both observations, some nodules looked to be at least a week old. Larvae usually began feeding close to the terminal buds (fig. 2).

The way in which nodules are made was determined by microscopic examinations at various stages of their development, and by direct observation of larvae transferred to new twigs. Both first- and second-year nodules start as silken tents spun by the caterpillars over future feeding areas. A larva begins feeding within the area enclosed by the tent. As frass accumulates and resin exudes from the feeding site, the larva incorporates these materials into the tent. The first young larvae found in 1955 were transferred to new host trees. Twenty-four hours later, all that established themselves had completed tents and were beginning to carry resin to them. As the larvae grow, they enlarge their nodules by excavating the old nodule wall and building new annexes.

The earliest new nodules built by second-year larvae after their migration were seen on April 17, 1953, in Ohio and April 24, 1955, in Maryland. Second-year nodules were usually at crotches formed by twigs arising from larger branches (fig. 3); however, 11 percent of 44 second-year nodules were situated on twigs away from crotches. The numbers of new second-year nodules on the tops, sides, and bottoms of nonvertical twigs were about equal. Larvae do not feed much in the spring before migrating. Fresh frass was found in abandoned first-year nodules, but no nodule annexes built just before migration were ever found. New annexes are resinous and red in contrast to the whitish, weathered surface of older nodule parts. Larval migration distances along 14 twigs and branches ranged from 1 to 36 inches and averaged 11 inches. Two out of 16 larvae apparently had not migrated but were using the first-year feeding site for the second year's feeding.

The larvae preferred to feed on the tissue between the bark and the pith. After removing a portion of bark and exposing this tissue, they sometimes tunnelled beneath the bark for short distances, but they periodically removed more bark.

Two series of observations show that just after hatching and during spring migration, larvae crawling on twigs may drop to lower limbs. First, nodules occurred below the oviposition zone only when larvae could drop from overhead branches. (The oviposition zone begins at about 5 feet above the ground.) Second, only 38 percent of 94 branches supporting second-year nodules also had first-year nodules.

Although migration of *Petrova wenzeli* larvae may seem hazardous, it has survival value. Virginia pine tends to produce shoots in greater abundance and of smaller diameter than many other pines. The larvae of the nodule maker can pass their first year on very small shoots, but the larvae grow faster than the shoots. After one growing season the shoots are often too small to continue supporting the larvae; moreover, many of the shoots are dead. Newly hatched larvae are probably not able to penetrate the bark of twigs older than currently developing shoots. Migration at the start of the second growing season to crotches of larger twigs therefore fills the need for more food and better shelter. The ability of first-year larvae to live on very small shoots helps to maintain populations on Virginia pine, especially on old trees where shoot growth may be slight.

The age of the twigs supporting 41 currently inhabited second-year nodules was determined. Thirty-two percent of the nodules were on 1-year-old twigs including the node between 1- and 2-year-old twigs ("1-2"); 36 percent were on "2-3"; 22 percent on "3-4"; and 5 percent each on "4-5" and "5-6."

After their second winter, larvae resumed regular activity early. On March 5, 1955, in Maryland, most inhabited second-year nodules showed new annexes. However, second-year larvae became active for short periods during the winter on warm days. The writers broke open one nodule in early December, and the damage had been repaired by the next visit two weeks later. If the second-year larvae undergo a winter diapause, it is not an intense one.

**Pupal stage.**—Before pupation, the larva makes a pupal cell of frass and resin within the nodule. Pupal cells tended to be oriented more vertically than horizontally. At the outer end of the cell, the nodule wall is eaten away till there remains a thin, slightly translucent area of the nodule wall, about as big around as the pupa. The larva lines the cell with a silk mat which excludes resin and probably aids locomotion. The pupa lies with its head toward the exit. In Ohio, 8 individuals seen on April 18, 1953, had pupated. In Maryland, 7 of the 18 individuals seen on March 26, 1955, and 7 individuals seen on April 27 had pupated. The pupal period lasted about one month.

**Emergence and adult stage.**—In the laboratory, about half an hour elapsed from the time emergence activity of one individual was first noticed till the new moth took flight. A circular motion of the head, indicating abdominal twisting, was

discerned through cracks in the exit as the pupa worked. The silk mat engaging the backwardly directed abdominal spines doubtlessly increased the traction of the spines. After 15 minutes, the pupa broke through and moved out in a matter of seconds. An examination of many empty pupal cases protruding from nodules showed that pupae moved out far enough to clear the encased wings. Seconds after the pupa in the present example was out of the nodule, the moth broke out of the pupal case.

Incipient moth emergence was noted in Ohio (insectary) on May 10, 1953, and in Maryland (field) on May 1, 1955. The periods of insectary emergence from 2 collections of nodules producing 12 and 35 moths lasted 11 and 16 days. The sex ratio of 35 adults was 1.2 males to 1 female. Males tended to emerge ahead of females: in the insectary, median male emergence preceded that of females by 6 days.

A mean of 33 eggs per female was deposited by 4 unmated females in a glass jar. The minimum preoviposition period of this group of females was about 5 days.

As a species with a 2-year life cycle, *Petrova wenzeli* presents the possibility of isolation of the even- and odd-year maturing populations. At all study sites, even- and odd-year individuals were present on the same trees, and the two populations were also of about equal size. The degree of genetic isolation of two such populations is a function of the extent of mutability of the life cycle. Observations of this mutability in *P. wenzeli* are lacking, but its existence seems certain. No apparent anatomical differences between specimens from the two populations were found. An adult is illustrated in figure 1.

#### HOST SPECIFICITY

The insect's striking host specificity for *Pinus virginiana* among the pines growing naturally in its range has been brought out in another paper (Miller and Neiswander, 1956). The literature contains host records for only *Pinus virginiana* (Busck, 1914; Doane et al., 1936; Heinrich, 1923; Miller and Neiswander, 1956; Schaffner, 1950; Smith, 1910; and U. S. Dept. Agric., 1953 and 1956). It is likely that Polivka and Houser's (1936) report of Virginia pine being infested by *Petrova comstockiana* (Fernald) actually involved *Petrova wenzeli* (Miller and Neiswander, 1956). There is a close resemblance of the color pattern of the *P. wenzeli* adult's forewing to that of the mature staminate flower of its host, and the adult flight period is concurrent with pollen bearing.

Jack pine, *Pinus banksiana* Lambert, was found infested with *Petrova wenzeli* at the one place where the writers saw this pine growing within the range of *P. wenzeli*. At Beltsville, Maryland, a few jack pine trees averaging about 10 feet tall had some nodules. Only one adult insect was successfully reared from the jack pine. This specimen was positively identified as *P. wenzeli*.

Attempts to induce oviposition and subsequent development on caged trees failed. More than 20 adults were introduced in various experiments into a 320 ft<sup>3</sup> gauze cage containing 9 young pine trees, but reproduction never took place. Twenty-one recently hatched larvae and 20 1-year-old larvae were transferred to the experimental pines, but none survived to pupation although about one-third of both groups succeeded in building new nodules. The caged pines were as follows: *Pinus virginiana*, *P. taeda* Linnaeus, *P. nigra* Arnold, *P. rigida* Miller, *P. densiflora* Siebold and Zuccharini, *P. resinosa* Aiton, *P. echinata* Miller, *P. silvestris* Linnaeus, and *P. strobus* Linnaeus.

#### VERTICAL DISTRIBUTION

In sparse Virginia pine stands, trees less than 5 feet tall were never found supporting *Petrova wenzeli* nodules. Apparently, oviposition does not take place at heights less than 5 feet. In the following discussion, the term "oviposition

zone" designates heights above this level. On trees which were taller than 5 feet and whose crowns also reached the ground, second-year nodules were found as low as 1 foot above the ground. Occasionally, saplings less than 5 feet tall were found to contain second-year nodules, but such trees were always growing very close to larger trees. The occurrence of nodules below the oviposition zone on such saplings and on tall trees can be explained by the dropping of larvae discussed earlier.

No upper limit to the oviposition zone was found. In Maryland, the crowns of a dozen felled Virginia pine trees at three places were examined. Nodules were present in the crown of every tree. Two of the fellings were in pure stands of Virginia pine while the third was in a mixed hardwood-Virginia pine forest.

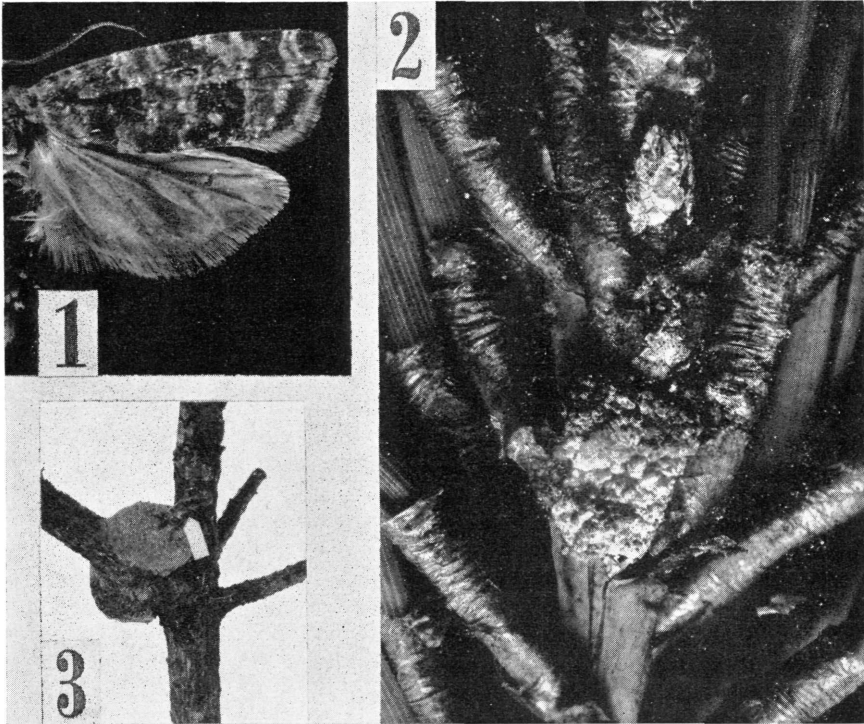


FIGURE 1. *Petrova wenzeli* adult from Ohio. Dark areas of the forewing are rust colored and the lighter markings are silvery white.

FIGURE 2. A new first-year *Petrova wenzeli* nodule on Virginia pine.

FIGURE 3. A second-year *Petrova wenzeli* nodule on Virginia pine with an empty pupal case (arrow) protruding. The second-year nodule has also been illustrated by Busck (1914).

Diameters of the examined trees ranged from 8 to 24 inches and annual rings counted from stump sections placed their ages between 25 and 75 years.

#### POPULATION DENSITY

*Petrova wenzeli* population levels seem to fluctuate very little: practically no variation in population density was noted among the 24 infestations observed in 4 states during this study. Also, high population levels have never been reported in the literature. A typical density is that reported by U. S. Dept. Agric. (1953) for an Ohio infestation. Of 21 trees between 5 and 8 feet tall sampled in a young

understocked stand of pure Virginia pine, 8 exhibited inhabited second-year nodules. Six of the trees had one nodule. Two trees had two and three nodules each. Many general observations suggest that the number of developing insects per tree is proportional to the extent of the crown area within the oviposition zone.

#### EFFECT ON HOST

The larvae feed first on needle bases, then on bark and cortex of twigs. Seven shoots infested by first-year larvae were observed for needle damage. Up to three needle clusters per shoot had tiny round holes through the sheaths indicating direct injury to needles. Still more needle clusters on each shoot had been injured after the direct needle feeding period by incidental feeding during expansion of the nodules. First-year larvae may also injure buds. In a sample of 13 infested shoots, 3 showed that 1 or more buds had been fed upon.

Many shoots attacked by first-year larvae die. Vigor seems to determine the fate of infested shoots. About half of infested lateral shoots were killed whereas a much smaller proportion of infested terminal shoots was killed.

Second-year larvae feed on that portion of the cortex beneath their nodules. The extent of injury caused by this feeding depends largely on the diameter of an attacked branch. The greatest injury seen was where the cortex had been removed 90 percent of the way around the branch. Up to 75 percent of branch circumference was often found with cortex destroyed. Cortex removal kills outright less than 1 percent of infested stems; however, it weakens branches and thereby contributes to breakage.

Doane et al. (1936) and Schaffner (1950) have mentioned the species briefly in treatises on economic insects.

#### MORTALITY

The caterpillar was commonly parasitized by *Hyssopus* spp. (Eulophidae). *Hyssopus* specimens from several places in Ohio were identified as *H. evetriae* (Girault) while specimens from Maryland were identified as *H. thymus* Girault. One caterpillar parasitized by *Agathis pini* (Muesebeck) (Braconidae) was found in Ohio. At least two successive *Hyssopus* generations (overwintering and one or more summer) attacked second-year larvae, with no appreciable difference in parasitization rate being observed in Ohio and Maryland. Spring observations of 44 larvae in new second-year nodules showed 14 percent parasitization, and winter observations of 83 larvae showed 7 percent parasitization. Both species of *Hyssopus* occurred externally and in aggregations of several individuals per host.

Nodule predation occurred sometimes at all study sites, but at two places in Maryland, birds preyed on an unusually large proportion of the pupae and mature larvae. A total of 50 second-year nodules examined at these sites on March 26, 1955, showed 56 percent recent predation. The attacked nodules contained solitary holes with occasional peck marks nearby. The size of most of the holes suggested a bird with a small, slender bill. The most likely suspect was the Carolina chickadee, *Parus carolinensis* Audubon (Beal et al., 1941).

Examination of 57 nodules in Ohio and Maryland just after moth emergence showed that 14 percent mortality from undetermined causes took place during the final 3 months of the life cycle.

#### ORIGIN AND GEOGRAPHIC DISTRIBUTION

The closest relative of *Petrova wenzeli* appears to be *P. albicapitana* (Busck), the northern pitch-nodule moth. The ecology of *P. albicapitana* (Turnock, 1953) is very similar to that of *P. wenzeli*, and specimens of the two strikingly resemble each other. The principal host of *P. albicapitana* is jack pine, a close relative of Virginia pine (Duffield, 1952). Noteworthy are these facts: first, that jack pine is the only species besides Virginia pine known as a host for the Virginia pitch-

nodule moth, and second, that introduced Virginia pine in Michigan is attacked by *P. albicapitana*. *Petrova wenzeli* and *P. albicapitana* are geographically isolated from each other by the isolation of their host species (Little, 1949). Isolation and speciation of the insects probably occurred by dispersal of adults from the range of one of the two pines to the range of the other. Dispersal across the *Pinus virginiana*-*Pinus banksiana* gap followed by interbreeding may be going on at the present time. Dispersal across this gap would probably have to take place by "mass flights" (Wellington, 1954).

The known distribution of the Virginia pitch-nodule moth is shown in figure 4. Three sources of distribution information were used: museum specimen records, the writers' own records (rearing and identifying the adult or noting work of the larva), and published records. Inquiries for specimens and distribution records were directed to eight museums and private collections. Authentic records were obtained from the U. S. National Museum, the Academy of Natural Sciences of Philadelphia, and the American Museum of Natural History. The writers

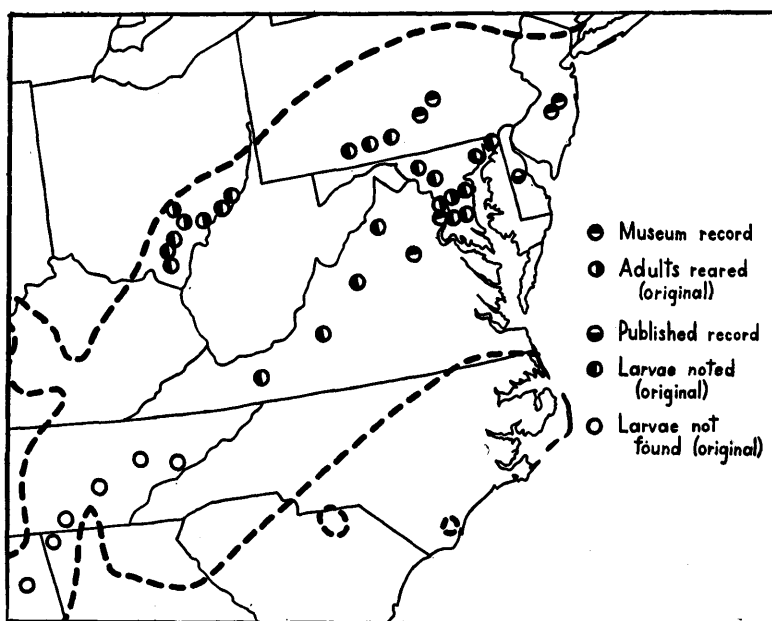


FIGURE 4. Distribution of records for *Petrova wenzeli*. The broken line represents the range limits of Virginia pine (after Little, 1949).

examined the specimens for each positive report and thereby eliminated several false records that were due to misidentifications. A wider distribution than could be shown on a point map has been reported for Delaware (U. S. Dept. Agric., 1956).

The listing of *Petrova wenzeli* on Nantucket and Marthas Vineyard Islands, Massachusetts, (Jones and Kimball, 1943) was based on misidentified specimens. J. F. Gates Clarke rechecked the Marthas Vineyard specimens which are in the U. S. National Museum and found they belonged to a different genus. The fact that Virginia pine is not included in Rice's (1946) list of tree species on Nantucket suggested the possibility of this error.

#### SUMMARY AND CONCLUSIONS

1. The biology of the Virginia pitch-nodule moth, *Petrova wenzeli* (Kearfott), was studied in Ohio during 1953 and in Maryland during 1955. The name of the species is herein changed to *P. wenzeli* from *P. virginiana* (Busck).

2. Under natural conditions, *P. wenzeli* attacks only Virginia pine, *Pinus virginiana* Miller, and its larvae build resinous nodules. The insect is known to occur in that part of the range of Virginia pine lying north of the 37th parallel.
3. The life cycle is normally two years long. Even- and odd-year generations occurred on the same trees. Larvae hatch during July and feed on new shoots. The following spring the partly grown larvae migrate to older twigs and branches. Pupation takes place the next March and April, and the adults are out in May.
4. Adults caged over young trees did not reproduce.
5. Oviposition occurs at heights ranging from the tops of old Virginia pine trees down to about 5 feet above the ground. Individuals developing below the 5-foot level probably drop from overhead branches just after hatching or during migration in the spring.
6. Population densities of the insect are low and seem to fluctuate little.
7. Larval feeding injures needles, twigs, and sometimes buds. Early feeding may kill shoots that are not growing vigorously. Later feeding destroys cortical tissue and weakens branches without killing them outright.
8. Larval parasitization is low and nearly all caused by either *Hyssopus thymus* Girault or *H. eveltriae* (Girault). Insectivorous birds may sometimes eat a large proportion of the pupae and mature larvae.
9. *Petrova wenzeli* and *P. albicapitana* (Busck) probably evolved from a common population following dispersal of adults across the gap separating the host species.

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